

Three Years

Lessons for Community Resilience

by Craig E. Colten, Robert W. Kates, and Shirley B. Laska



New Orleans proved that it could recover from 27 major floods before Hurricane Katrina overwhelmed its levees in August 2005, flooding 80 percent of the city, causing some 1,300 deaths, forcing an extended evacuation, relocating (perhaps permanently) 100,000 residents, seriously damaging 70 percent of the city's residences, and disrupting basic municipal services, econom-

ic activity, and social networks. The monetary loss to the city is estimated at \$40-50 billion.

Three years after Katrina, levees have been partly rebuilt, the equivalent of two-thirds of the pre-storm population has returned, building permits for 30 percent of residences have been issued, and the hospitality economy has been restored. But large areas of the city are empty tracts, mainstays of the economy in medicine and

after Katrina



education have not recovered, planned reconstruction is just beginning, and some communities may be lost forever.

The city's ability to rebound from repeated encounters with high water in the past relied heavily on short-term flood protection remedies, rather than the more sustainable strategy of enhancing overall community resilience. Resilience enables communities to rebound

from disaster and reduce long-term vulnerability, thus moving toward more sustainable footing. Considering New Orleans's situation in light of four key elements of resilience—anticipation, response, recovery, and reduced vulnerability—provides lessons that are quite different from the bureaucratic messages produced by the White House.¹ It is critical to build these into future, more sustainable preparations.



At the peak of flooding after Hurricane Katrina hit New Orleans on 29 August 2005, 80 percent of the city was underwater, with depths up to 15 feet.

Elements of Resilience

The Community and Regional Resilience Initiative (CARRI), a federally funded program that seeks to help communities put in place policies, practices, and processes that will enable them to become more resilient in the face of hazard events, defines resilience as “a community or region’s capability to prepare for, respond to, and recover from significant multihazard threats with minimum damage to public safety and health, the economy, and national security”² (see Figure 1 on page 39). According to this definition, enhancing a community’s resilience is to improve its capacity to anticipate significant multihazard threats, reduce the community’s overall vulnerability to hazard events, and respond to and recover from specific hazard events when they occur. While most communities have some emergency management framework for hazard

response, other elements of community resilience—for instance, hazard anticipation, vulnerability reduction, and disaster recovery—commonly are fragmented.³

Anticipation of multihazard threats begins with hazard identification; takes form with specific event monitoring, forecasting, and warning; and includes recognition of the need to prepare for, respond to, and recover from such events. Resilient communities have in place integrated emergency institutions and communications; formal disaster plans; trained first responders; multihazard event response exercises; a reserve of personnel, material, and financial resources; public education and information; and continuing long-term planning for recovery and vulnerability reduction.⁴

When a hazard event or multiple events are about to impact a community, a set of emergency responses ensues. These include issuing and widely disseminat-

ing unambiguous forecasts and warnings, undertaking evacuations or providing alternative shelter, and mobilizing emergency responders and reserves. Following the event, emergency responders undertake search and rescue; care for and treat casualties, evacuees, and the sheltered; find, remove, and identify the dead; conduct damage and needs assessments; and restore order. The emergency period overlaps with a restoration period, where the repairable essentials of urban life are restored, which in turn overlaps with a reconstruction period to provide the infrastructure, housing, and jobs for the destroyed city and pre-disaster population, as well as commemorative or betterment reconstruction.

Disaster recovery addressing the long-term needs of disaster victims and community is both physical and social.⁵ Cities and regions seeking to recover after a disaster seem to simultaneously pursue goals to rapidly recover the familiar built

environment and social-economic activities and reconstruct in safer, better, and sometimes in more equitable ways. Resilient communities recognize that conflict will sometimes arise between groups, institutions, and individuals pursuing these different goals; try to plan for them and resolve differences beforehand; and then balance them during reconstruction. Political and economic power most often determine the outcome, and the outcome is often not in the interest of the vulnerable.

A key to increasing community resilience is to reduce its overall vulnerability—the potential for harm and social disruption from multihazard threats before hazard events occur.⁶ By limiting exposure to the hazard, diminishing the direct impacts of hazard events, and sharing the losses from such events, communities can mitigate hazard threats. Essential to post-disaster resilience is building an ongoing community-wide commitment to respect all segments of the community and be inclusive in decisionmaking processes and resource allocation. These measures build trust in advance of the next disaster.

Assessing Resilience in New Orleans

Over the course of nearly three centuries, local and federal organizations collaborated to erect extensive flood-protection systems, establish hurricane and river flood forecasting, and formulate evacuation plans in New Orleans. Yet the city's reaction to Hurricane Katrina can hardly be described as resilient. How did the city anticipate, respond, recover, and seek to reduce vulnerability during and immediately after the storm, and what does this tell us about the city's future resilience?

Anticipation

As Hurricane Katrina moved toward Louisiana in August 2005, the National Hurricane Center offered precise warnings 32 hours in advance of landfall and tightened the accuracy of its projected landfall zone.⁷ In response, Louisiana Governor Kathleen Blanco unambiguous-

ly mobilized state emergency preparedness agencies and the National Guard.⁸ But once the storm hit the area, it became clear that there was inadequate anticipation of the fragility of the communication systems and the loss of power that disrupted the emergency response. Most critically, agencies did not anticipate that flooding would bar the Red Cross and other rescue groups from entering the city or that desperation and looting would follow once meager food and water stockpiles were exhausted.

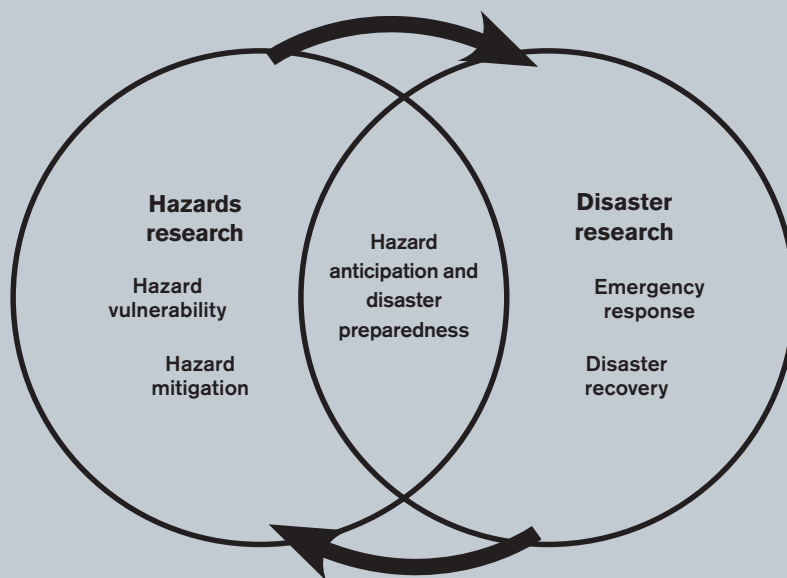
Yet despite the large role of communication and organizational failures in the disaster following Katrina, planning for future storms focuses largely on infrastructure repairs and some improvements. At the core of New Orleans's future planning is a determination that levees will be rebuilt to a modest, 100-year storm standard along with a surge barrier east of the city. This requires levees be built to withstand a storm that has only has a 1 percent probability of occurring in

any year. The state's Louisiana Recovery Authority issued a report that anticipates future hurricanes and includes a blend of coastal restoration and improved levee protection to fend off future storms.⁹ But while the report calls for sustainable development, it also recommends creating economic development in some of the area's most vulnerable locations.

Response

After receiving a stern warning from the National Hurricane Center, New Orleans Mayor Ray Nagin declared a mandatory evacuation of the city on 28 August and opened the Superdome as the refuge of last resort.¹⁰ By the next day, some 1.2 million residents of the metropolitan area evacuated primarily by private auto and took shelter across the Gulf Coast region, where the Red Cross and the military set up staging centers.¹¹ Meanwhile, some 130,000 New Orleans residents and visitors tried to ride out the storm (a number

Figure 1. Hazards and disaster research



SOURCE: Adapted from National Research Council Committee on Disaster Research in the Social Sciences: Future Challenges and Opportunities, *Facing Hazards and Disasters: Under Human Dimensions* (Washington, DC: National Academies Press, 2006)

equivalent to those without private transportation¹²).

When Katrina passed over the area, levees unexpectedly failed in some critical areas, and floodwaters overtopped them in others (see Figure 2 on page 41). At the peak of flooding, 80 percent of the city was underwater. Depths ranged from a few inches to more than 15 feet. The U.S. Army Corps of Engineers commenced emergency levee repairs immediately. Ad hoc voluntary rescue efforts in affected neighborhoods were critical to the survival of many in the early post-storm hours. As soon as the winds subsided to safe levels, the U.S. Coast Guard and Louisiana wildlife and fisheries crews launched rescue operations aided by volunteer boat owners, although many rescuers were unfortunately turned away.

Despite plans and exercises to prepare for events of this sort, the extreme conditions overwhelmed institutional responses at all levels.¹³ For example, an extensive emergency apparatus in the city's hospitals failed when floodwaters disabled emergency generators, leaving patients and staff in sweltering conditions. Although medical personnel remained to serve patients, conditions quickly turned deadly before a hasty, after-the-fact evacuation moved patients out of the city.¹⁴

Within a week after the storm's arrival, some 1,500 perished in Louisiana, most in New Orleans. The city was left with more than 134,000 (of 188,000) damaged residential units.¹⁵ With a second inundation from Hurricane Rita in late September 2005, it took 53 days from Katrina's landfall to pump the city dry. From 12 October on, emergency operations yielded to recovery efforts. Levee and infrastructure repairs took longer than anticipated and delayed related responses.¹⁶

In Katrina's wake, both Louisiana and New Orleans have updated their respective response strategies.¹⁷ By mid-2007, Louisiana had thoroughly revised its Emergency Operations Plan¹⁸ for evacuation, shelter, and the role that each state agency is to play in the event of an emergency. The "all-hazards" operational plan calls for the deployment of local resources until they are overwhelmed, then it makes



Two years after Katrina, the chalkboard of an irreparably damaged Lower Ninth Ward school retained most of the writing from before the storm hit.

state and federal resources available. Left out are non-agency actors, who proved crucial to response and recovery in New Orleans. As with many of the resiliency efforts, volunteer and nongovernmental stakeholders' participation represents a key to successful government programs. Such a partnering requires a paradigm shift that is only beginning to emerge from the Katrina experience.

Recovery

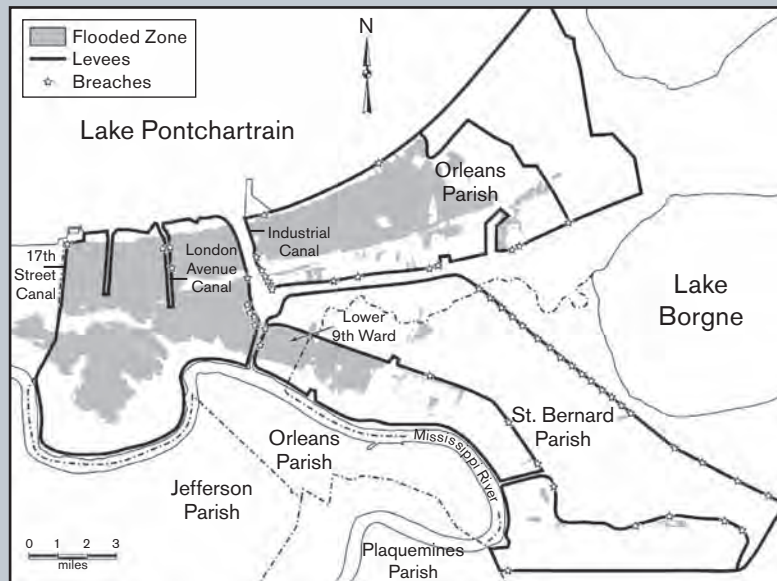
Mayor Nagin focused his initial recovery efforts on restoring New Orleans's basic infrastructure and the economy. Massive amounts of construction funds are destined to keep the economy going for at least two years, but only a fraction of Federal Emergency Management Agency (FEMA) infrastructure funds released to the state have reached New Orleans. The city's economy remained below pre-storm levels in late 2007 but was above previous estimates, suggesting a somewhat stronger-than-anticipated

recovery.¹⁹ In particular, the long-term recovery of the hospitality industry has been good, and, buoyed by major sports and entertainment events, hotel and motel tax revenue for early 2008 climbed to near or above pre-Katrina levels.²⁰

Higher education and medicine, mainstays of the economy, suffered long-term blows from the storm. Reduced staffs and below-normal enrollment have stymied the full recovery of universities.²¹ Hospital closures have left a major gap in health care, especially for mental illness. The city has only about three-quarters the pre-storm hospital capacity²² and still faces a major loss in skilled medical jobs, and consequently physicians continue to leave the area.²³ Maintaining adequate, qualified staff is a continual challenge for health care institutions.

At the one-year mark, the Brookings Institution reported severe housing and labor shortages, and even basic utilities such as gas and electricity were reaching a fraction of the pre-storm customer base (mostly due to slow return of custom-

Figure 2. Levee breaches and flooding after Hurricane Katrina



SOURCE: E. Yodis and C. E. Colten, *Geography of Louisiana* (New York: McGraw-Hill, 2007).

ers). The city's population stood at 49 percent,²⁴ and only 29 percent of schools were open 12 months after the storm.²⁵

By early 2008, about 141,000 households had resumed mail delivery, close to 71 percent of the pre-storm total,²⁶ while many former residents have remained on higher ground in Louisiana or in nearby states.²⁷ More than 105,000 houses needed substantial repairs, and with delays in recovery funds, slow insurance payments, and inadequate labor to effect repairs, rehabilitation of the existing housing stock has been sluggish.²⁸ FEMA's program to phase out trailers as temporary shelter²⁹ has accentuated a major shortage of affordable housing, a situation that has become increasingly desperate as the Federal Housing Administration proceeds with its plan to demolish some 4,500 public housing units and replace them with mixed-income, mixed-use development.³⁰

On a more positive note, restoration of some community organizations has been healthy,³¹ and volunteers and nonprofits have played a significant role in restoring

housing and providing essential services.³² Their success is contributing to the understanding of the role of such groups in future community resiliency.

In the years after Katrina, developing a viable and acceptable official recovery plan has proved to be a torturous process. After several efforts floundered, the community-based Unified New Orleans Plan received approval in summer 2007.³³ It does not include a major overhaul of land use, and tensions linger between those who feel residents have the "right to return" and those who argue that land development in the most vulnerable areas of the city should be restricted or prohibited.

A more encouraging development is that the city proposes to build constant reassessment of hazard mitigation plans and recovery into the city's long-term plan.³⁴ In addition, the state's Emergency Operations Plan includes recovery as a basic part of its response to future hazard events with recovery coordinators and state Department of Economic Development officials playing a key role.³⁵ Yet there

are no specific plans, only a broad-brush agenda for officials to keep recovery as a fundamental component of planning with no assurance that it will be maintained in the future. Sustained recovery still relies on a secure levee system and other appropriate measures of risk reduction. The U.S. Army Corps of Engineers has projected 2011 as the date when the levee system will be certified at the 100-year level. Its risk and reliability analysis, a risk assessment designed to offer the public detailed maps of local flood risks, has been the object of criticism, particularly since it does not consider environmental justice. Public skepticism, rooted in impacts from past floods, lingers over the corps' ability to provide adequate protection for that flood-susceptible areas.³⁶

Vulnerability Reduction

Vulnerability reduction during the storm took the form of structural protections, primarily levees that failed in some places, and evacuation, which worked for the two-thirds of the population able to drive out of the city. Since the storm, repairs to more than 200 miles of levees and associated pumps, along with more inclusive evacuation plans, are key elements of reduction. But local residents and officials share significant cynicism about the safety of the levees and the degree to which large bureaucracies, namely the U.S. Army Corps of Engineers and FEMA, are able to achieve their designated missions.

Thus, since Katrina, redundancy of safety efforts, including local self-sufficiency, have emerged as resiliency actions. State planning now stresses the need for multiple lines of defense—this includes levees, raised structures, coastal restoration, and evacuation.³⁷ Government agencies have installed stronger levee supports at the site of breaches along with gates and temporary pumps at the mouths of outfall canals. Surge-dampening structures east of the city are part of the ongoing projects, but they could displace the threat to adjacent communities including those in Mississippi. Coastal restoration plans also factor into reducing impacts in the very distant future.³⁸

Hurricane evacuation improvements focus on increasing the sensitivity of public officials to the needs of the economically, physically, and age-vulnerable populations and to improve coordination at all levels. The nongovernmental stakeholder groups for these vulnerable groups have been in the forefront of advocating and providing resources to work toward the goals. But absent to date has been the concern that even improved evacuation plans will fail, and there is need for redundancy in providing alternative local shelters of last resort or from modest storms.

Another layer to state planning is architectural. The Louisiana legislature enacted new building codes for areas outside New Orleans (which already had the latest design standards for new buildings). In the city, local government adopted revised FEMA Base Flood Elevation Levels for new construction.³⁹ These require inhabited floors to be at least three feet above the adjacent grade or the local Base Flood Elevation (whichever is higher) to protect from flooding. Local residents must raise their houses or the community risks loss of access to flood insurance. Already individuals are raising houses using funds from three separate programs that pay up to \$90,000 per house.⁴⁰ Yet these programs rolled out 2.5 years after the storm, a delay that hindered rapid restoration of houses. Furthermore, the three-foot elevation in FEMA's provisional standards is clearly insufficient to prevent major flooding in the future.

Other insurance has become more costly and difficult to obtain.⁴¹ This has presented obstacles to those wishing to rebuild and discourages return to vulnerable locations. State programs to encourage insurance companies to write policies and a state-operated last-resort insurer are in place.⁴² No significant improvement in the cost and willingness of the companies to write insurance is expected in the near term.

At the state level, planners and legislators have several adjustments to reduce the impact of future storms. The state has revamped its all-hazards emergency plan that was incomplete before the storm.⁴³ Also, the state legislature consolidated the numerous parish levee districts in southeast

Louisiana into two districts—one on either side of the Mississippi River—and created the Louisiana Recovery Authority (LRA) to oversee regional recovery planning. The LRA plan also calls for multiple lines of defense that include effective evacuation plans and restoration of barrier islands and coastal wetland, backed by levees along with other nonstructural defenses.⁴⁴

Lessons Learned from Katrina

New Orleans, like many cities, was a catastrophe waiting to happen, with extensive and repeated warnings from both scientists and the media. The pre-Katrina estimated population of 437,186 lived in a bowl, half below sea level, between the natural levees of the Mississippi River and the built levees (pierced by canals) along Lake Pontchartrain. Katrina brought severe but not catastrophic winds, record rainfalls, and stormwater damage, followed by the collapse of major canal floodwalls allowing water to fill the bowl in about 80 percent of the city. The human and social disruptions have been extraordinary.

Through extensive media coverage, the world saw remarkably inadequate rescue operations, the failure of complete evacuation, the collapse of the levees, the subsequent out-migration, and the plight of those remaining in the city, with the burden falling heaviest on African-Americans and poor, aged, and infirm members of the population. What amazed many worldwide was that these extensive failures, often attributed to conditions in developing countries, occurred in the most powerful and wealthiest country in the world. One of the most humbling lessons is that the greatest overall disaster in U.S. history occurred at a time of unprecedented U.S. wealth and power.

Katrina also taught us to expect the unexpected. Every hazard event brings these surprises and every disaster even more. These come from unanticipated events, anticipated events but failed responses, or anticipated events that are proved wrong by experience. A central task for resilient communities is to con-

sider the surprise experiences from other disasters, try and anticipate unexpected problems, and plan for redundancy in emergency response and recovery.

In New Orleans, one surprise quite commonly led to additional surprises. The levee failures begat emergency power failure at hospitals. Flooding prompted officials to prohibit the entry of emergency responders like the Red Cross. Each surprise compounded the difficulties faced by residents and public officials alike, and complicated even flexible contingency plans.

In addition, improving the elements of community resilience takes many years. Protective levees had been under construction for 40 years, and it took the city nearly 20 years to devise what amounted to incomplete recovery plans. The actual emergency response period following Katrina took at least six weeks, longer than any similar disaster in U.S. history. The restoration period to rehabilitate repairable infrastructure took about a year, a lengthy period for those waiting for services, but somewhat faster than would be predicted by the exceptional length of the emergency period. But to develop a community-acceptable reconstruction plan took 21 months and to reconstruct after Katrina will take at least a decade more.

A closer look at lessons learned at each stage of the process—anticipation, response, recovery, and vulnerability reduction—may help illuminate a more comprehensive, effective, and equitable approach for dealing with hurricanes and other hazard events in the future.

Anticipation

• *Long-term anticipation and short-term warning systems took time to develop, were effective, and yet were insufficient to induce sufficient community resilience.* An extraordinary event like Katrina had been partly experienced when the Category 3 Hurricane Betsy struck New Orleans in 1965. Moreover, it had been anticipated by the expert community for many years, reported on publicly three years before Katrina in a widely disseminated account in the newspaper,⁴⁵ and simulated in an emergency exercise a year before Katrina. Even



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Residents of New Orleans board a military helicopter during the longest emergency response to a U.S. disaster of Katrina's magnitude.

earlier, the Weather Bureau began monitoring and offering predictions on hurricanes in the nineteenth century and had initiated a formal coordinated effort to track and offer warnings by the mid-1960s. By the time of Katrina, the actual warning of the event was excellent, having been tracked publicly for four days, with the time and location of the storm track forecast accurately to within 24 miles, a full day before it came onshore.⁴⁶

Yet despite such anticipation, the protective works were both incomplete and failed, and Louisiana's emergency plan had not been updated. Utility and transportation companies did have their own recovery plans, but there were no plans, public or private, for reconstruction. Furthermore, the event occurred before planning and preparation were complete.

- *Best available scientific and technological knowledge was not used or widely disseminated.* Following Hurricane Betsy in 1965, engineering designs for new and improved protective works took into account the estimated frequency and magnitude of a standard project hurricane and the effects

of storm surge, land subsidence, and rising sea level as measured at that time. But 19 years later, these estimates were still being used when subsidence within the levees had lowered the land surface by 10 feet, sea level had risen by approximately 7 inches, and storm waves and surges had risen by proportional amounts.⁴⁷ The multi-decadal rhythm of frequent hurricanes presents periodic threats and the possibility more intense hurricanes due to global warming may compound local risk. Publicly available risk assessments remained similarly uninformed: no FEMA maps of the 100-year floodplain ever included sea-level rise or land-subsidence effects. Now, however, FEMA is relying on the best science in terms of local subsidence. Most of the responsible agencies have not embraced data on sea-level rise.

Response

- *The emergency response period to Katrina took longer than any similar disaster in U.S. history.* An emergency

response period is characterized by search and rescue, emergency shelter and feeding, the establishment of order, the clearing of major arteries, and, for floods, water drainage. Before Katrina, the most comparable disaster on record, the San Francisco earthquake of 1906, had an emergency period of 4 weeks. Yet it took 6 weeks to pump and drain floodwaters from New Orleans in the wake of Katrina and 14 weeks to end emergency shelter. The extended period was partly due to secondary flooding from Hurricane Rita, but in retrospect, the major causes of the extended response were the failures of anticipation, planning, responsibility, and execution.

- *Non-agency actors provided major capability and resources, but were ignored or poorly used by the emergency response structure.* Emergent individuals or organizations that respond to unaddressed needs are characteristic of all disaster responses. These "shadow responders" often come from households, friends and family, neighborhoods, nongovernmental and voluntary organizations, businesses, and industries.



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Owners of a damaged house near the 17th Street Canal breach express dissatisfaction with a low insurance payment.

In New Orleans, these groups and individuals provided most of the initial evacuation capacity, shelter, food, health care, and rebuilding—and much of the search and rescue, cleanup, and post-Katrina funding. Yet government officials often refused or poorly used groups, such as Catholic Charities or the Council on Aging. They would have been able to do more if the trilevel system (city, state, and federal) of emergency response was able to effectively use, collaborate with, and coordinate the combined public and private efforts. Since the storm, government authorities have continued to discount the capacity and expertise of nongovernment organizations. Reshaping government agency respect for the role these organizations can play a central role in enhancing community resilience.

- *Elements of multihazard response capabilities were in place, but shifting priorities disrupted the ability to transfer capabilities from one hazard response to another.* The New Orleans medical community had endured numerous hurricanes and provided some of the most active members of the local emergency preparedness committee,

but over the years their preparation was inadequate to respond to the crises created by Hurricane Katrina. Medical training and care provided less preparation for geophysical events than biological threats. From Civil Defense preparations during the 1950s and 1960s to recent Homeland Security preparations, national military priorities sometimes have overshadowed the more commonplace and repetitive events such as hurricanes. For example, insulin was the needed drug for stranded residents, not an antidote for bioterrorism weapons. Diversion of resources within FEMA and the National Guard to a homeland defense agenda left both organizations below full strength for responding to an event like Katrina. Additionally, while the numerous organizations involved in emergency response and recovery have distinct and often effective responders, they seldom work together.

Recovery

- *Recovery took longer than anticipated.* After disasters, local boosters,

officials, and residents often promise to rebuild in a short time, but their rhetoric is seldom realized. Underappreciated is the long period of time that actual recovery requires, especially after a catastrophe such as Katrina. Recovery can be divided into three periods. Before the emergency response period is over, a restoration period ensues where the essentials of urban life that are repairable are restored. And before it is over, a period of reconstruction begins to replace the destroyed infrastructure, housing, and jobs to reaccommodate the pre-disaster population. This is often followed by or overlaps with a period devoted to commemorative or betterment reconstruction, usually major projects of memorial and/or civic improvement.

In New Orleans, the restoration period lasted for a year. Based on our expectation that the period would be 10 times the length of the emergency period (at least 60 weeks), the period was somewhat shorter than expected. This shorter restoration period can be explained either by the major commitment of funding, resources, and leadership or that the



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Habitat for Humanity's Musical Village is one of many examples of nonprofit and individual efforts to rebuild in New Orleans.

shorter year-long restoration period better reflects the historic scale of experience in other recovery efforts.⁴⁸

But the reconstruction period seems destined to take longer than expected. Plans for reconstruction began to circulate even within the emergency period, but development of an acceptable plan took 21 months.⁴⁹ Thus reconstruction is clearly on track to last 10 or more years (10 times the restoration period). But it is also likely that reconstruction will never be sufficient for the pre-disaster population, as current estimates project a long-term population substantially smaller than the pre-disaster population.

- *Recovery was slowed by unanticipated conflict over processes and goals of reconstruction.* New Orleans underwent an extremely long planning period for reconstruction, consisting of five different planning processes. Poles of contention developed over whether the process should be top-down or bottom-up, with a mayoral top-down, outside-expert initiative evoking a strong neighborhood-inspired, city-council authorized counter-effort. This

was replaced by an externally funded, expert-supported, unifying process.

But underlying the differences in approach are the all-important differences in goals. In New Orleans, efforts to slow rebuilding to allow time for assessment, planning, and reconciliation were resisted or circumvented in favor of rapidly recovering the familiar. Efforts to accept a safer, better New Orleans with a smaller geographical footprint and reclaimed areas dedicated as green space and rainwater storage were similarly seen as efforts to destroy existing neighborhoods, especially those with large poor and black populations.

- *Disasters accelerated existing pre-disaster trends.* Recovery following disaster generally follows the pre-disaster trajectory with the disaster even accelerating previous trends. Thus New Orleans, whose population had declined 31 percent from a peak 1960 Census estimate of 627,525, lost two-thirds of that population after Katrina, with a refugee population still scattered in all 50 states. The economy was also declining pre-Katrina, and despite the inflow of recovery mon-

ies, after peaking in 2006, the number of building permits declined during the last quarter of 2007. To escape this gloomy trajectory, current New Orleans recovery planning has identified 17 target recovery areas to serve as reconstruction clusters. Some other business clusters in heavily flooded areas have made strides toward restoration in early 2008.

Vulnerability Reduction

- *Despite more than 290 years of effort, overall vulnerability to hurricanes has grown.* Geophysical vulnerability in New Orleans is marked by its bowl-shaped location partly below sea level, accelerating subsidence, rising sea level, storm surges, and possible increased frequency of larger hurricanes. These partly natural phenomena have been enhanced by human location decisions, extraction of groundwater, oil, and natural gas, canal development, loss of barrier wetlands, internal rainfall storage, global warming, and the design, construction, and failure of protective structures. In addition,

nineteenth-century drainage canals have actually enhanced inflows to the city. Reducing vulnerability from river flooding has been successful to date by building protective works to a high protection standard and employing diversion outlets for floodwaters. Hurricane protection has used a lower protective standard, and protection projects both before and after Katrina were not completed. Commenced after Hurricane Betsy in 1965, the U.S. Army Corps of Engineers' Lake Pontchartrain, LA, and Vicinity Hurricane Protection Project failed to meet its initial completion date of 1978 but finally was nearing completion in some sections by the time of Katrina. Following Katrina, the Corps had patched the breaches within one year but projected it would take at least six years to restore the levees to their pre-storm design configuration. In addition, the Corps was only beginning to study the costs and benefits of a higher protection standard (for category 4 and 5 hurricanes).

Equal to or greater than the increase in geophysical vulnerability has been the increase in social vulnerability. Following Hurricane Betsy in 1965, new levees and internal drainage encouraged new development in low-lying areas, placing an additional 150,000 households across the metropolitan area in harm's way. Subsequent loss of population within the city diminished this trend somewhat, but selective population loss ("white flight") may have enhanced the social vulnerability and subsequent failure to respond to distinctive needs of the elderly, the poor, and households without autos. A poorer, older city was clearly more vulnerable to Katrina, and no planning to date has addressed poverty reduction or youthful in-migration to reduce future vulnerability. Indeed, cynics point out that policies adopted to discourage poor people from returning (for instance, reduced public housing) are one immoral way to reduce such vulnerability.

• *Efforts to provide protection reduced vulnerability to frequent small events, but increased vulnerability to rare catastrophic events.* In the 40-year span between Hurricanes Betsy and Katrina, protective

works—new and improved levees, drainage pumps, and canals—enabled massive development of previously unprotected areas. The partly completed projects successfully protected New Orleans and surrounding parishes against three hurricanes in 1985, 1997, and 1998. But these works were the basis for the catastrophe of Katrina and its flooding when the works themselves proved inadequate.

Closing Comments

Three years after Hurricane Katrina, multiple steps have been taken to improve community resilience—in terms of anticipation, response, recovery, and reducing future impacts. In many cases, the adjustments have flowed from the lessons learned in the immediate aftermath of the storm. Over the city's long history, and in the absence of a specific resilience framework, elements of resilience have ebbed and flowed through the area's efforts to deal with events such as hurricanes. Certain elements have weakened, while others have grown stronger. This is true for the post-Katrina period. Resilience during the emergency period improved as the response progressed. It was highly inconsistent during the restoration period, even as substantial progress on restoring basic physical and social infrastructure took place. As formal elements of resilience are put in place, the pace of reconstruction has slowed. The question remains how effective the new resilience measures will hold up under the pressure of another hazard event.

What sets resilience in human communities apart from biotic communities is the capacity to learn from past experiences and employ strategies to contend with future events. Central responses to the lessons learned from Katrina include expecting the recurrence of major hazard events, greater future vulnerability, and the failure of important elements of community resilience. Given the unlikelihood in the next two decades of citywide vulnerability reduction beyond the current level, local vulnerability can be reduced with safer construction practices, greater concentration of population on higher ground, erection

of elevated schools that can double as neighborhood refuges of last resort or from modest storms, and effective use of local nongovernment groups and organizations. Overall community resilience can be maintained and enhanced only when the commitment to it is so strong that it is integrated into all ongoing community development activities.

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The authors recognize the efficient and thorough research effort undertaken by Amy Sumpter and Sarah Stack to make this report complete. Also, we thank Clifford Dupelchin for his excellent illustrations and the editors at *Environment* for their prompt attention to our manuscript. This research was funded as part of the Oak Ridge National Laboratory Community and Regional Resilience Initiative (CARRI). An extended version of this paper has appeared as CARRI Research Report no. 3. This version is published with permission of CARRI. The authors retain copyright.

NOTES

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